TECHNICAL RELEASE

NUMBER 25

DESIGN OF OPEN CHANNELS

CHAPTER 1. GENERAL CONSIDERATIONS

This guide defines the technical aspects of open channel planning and design. Channel design involves the fields of hydrology, geology, hydraulics, drainage, irrigation, erosion control, soil mechanics, landscape architecture* and structural design. Adequate planning and design require close coordination of these technical fields.

Open channels are used to serve a variety of functions. These include flood protection, drainage, irrigation, diversion of water to control erosion and sedimentation, and for recreational and other purposes, either singly or in multiple purpose combinations.

The contents of this technical release are primarily directed at the design and planning of floodways and open channels where channel erosion is of primary concern. The planning and design of low gradient channels such as irrigation canals, drainage ditches, grassed waterways and so on are covered in other service handbooks.

Channel Planning

The objectives of the project first must be clearly defined. The level of development or adequacy of improvements for each purpose and the general location and layout also needs to be resolved in early stages of planning. Economic and other factors which are outside the scope of this guide should be considered with the engineering alternatives, based on the procedures presented herein.

After the functional requirements of the channel have been determined in planning channel work, the following steps in preparing open channel plans and design are necessary:

1. Field surveys to provide topographic information and other physical data pertinent to location and hydraulic and structural design.

2. Geologic and soil investigation and testing of soil materials for planning and design requirements.

3. Analysis of hydrologic or other conditions to determine channel capacity needed to meet project objectives.

* A Glossary of technical terms for Landscape Architecture may be found in Chapter 2, Appendix A.

4. Analysis of geomorphology viewsheds, visual resource values and landscape use values to determine visual resource planning and design requirements.

5. Use of the above data in developing the engineering aspects of project formulation.

In the formulation stage, physical conditions should be determined and an appraisal should be made of other limitations imposed on channel work that might limit functional performance in meeting objectives. These include:

1. Adequacy of outlets to handle required flow without excessive scour or deposition, and without damaging downstream flooding.

2. Protection of water rights.

3. Availability of rights-of-way.

4. Satisfying minimum flow requirements.

5. Environmental considerations including landscape resources that must be conserved.

Adequacy of Outlets

Basic requirements. - - In determining adequacy of outlets, the following basic requirements should be met:

1. The capacity of the outlet should be such that the design flow from its watershed can be discharged into it at an elevation equal to or less than that of the hydraulic gradeline that is used for design of the project. The storm used for this analysis should have the same chance of occurrence as the storm used for design of the improvements.

2. Where subsurface drainage is needed, the depth of the outlets should be such that subsurface drains may be discharged into it above normal low water flow.

3. The capacity of the outlet should be such that the discharge from the project watershed, after proposed improvements, will not result in stage increases that will cause significant damages below the termination of the project channel.

4. Flow conditions in the outlet should be capable of maintaining equilibrium with the sediment transport of the project channel. There should not be excessive scour or deposition of sediment in the outlet.

Evaluation of project effects. - - Many items must be considered in evaluating project benefits, among these are:

1. The stage-discharge relationship of the project channel, including overbank-flow, should be determined for "before" and "after" project conditions.

2. Stage-discharge curves for the outlet should be developed by computing the water surface profile through two or more cross sections below the outlet using the existing roughness coefficient.

3. The effect of project improvements on stages in the outlet should be analyzed for storms of at least two recurrence frequencies. Storm frequencies selected for the analysis should be that used for project design and one other significantly different from the design discharge.

   Procedures outlined in National Engineering Handbook, Section 4, Hydrology, Part 1, Watershed Planning, shall be used for the analysis.

4. Where downstream effects of channel improvement are significant (stage increases will cause damages below the termination of the project channel) an analysis to determine effects should be carried downstream to the point where effects have been dissipated.

5. Geologic and soil investigations to determine the effect of project improvements on the stability of the outlet should be made as outlined in Chapter 3, "Site Investigations."

Special outlet conditions. - -

1. Tidal Influence. Where channel improvements discharge into rivers, estuaries, bays, and sounds, which are subject to tidal influence, the effect of the tides on discharge from the channel should be determined. This is true if the outlet is a tidegate, which opens and closes according to the relative elevations of the tide and the hydraulic grade of the channel; or if the channel discharges directly into tidewater, without a tidegate.

   The characteristics and types of tides are discussed fully in "Tidal Datum Planes."1/ Annual editions of "Tide Tables, High and Low Water Predictions" are available from the Coast and Geodetic Survey, U.S. Department of Commerce.

2. Pumping. Where the project is provided with pumps to discharge the runoff from the watershed, the area may be protected by levees.

1/ Numbers refer to numbered references at end of this technical release.

In this case the levees should meet the National Engineering Standards for Dikes and Levees, the pumping capacity should be adequate for the design runoff, and the outlet into which the pumps discharge should meet the basic requirements for outlets.

Legal Requirements

Applicable provisions of state water laws must be met in all channel work. Existing water rights may require protection or rebuilding of diversion works, control structures for regulating flows, etc.

Preliminary investigations should determine the existence of any water rights on channels to be improved and the limitations that they may impose on the improvements.

Rights-of-Way

Acquisition of rights-of-way is an essential element of channel improvement. Careful consideration of this element from the preliminary investigation or reconnaissance stage through the construction stage will greatly expedite the job and reduce its cost. Certain modifications of location and alignment, within the limits of good design, may be made to ease rights-of-way problems.

Environmental Considerations

Landscape resources shall be given full consideration from the preliminary investigation through final inspection. These resources include visual, fish, wildlife and recreational and may include areas outside of the right-of-way that are affected environmentally as a result of the project. A guide for planning and design considerations related to wildlife, fish and recreation resources may be found in Chapter 7.

A guide to visual resource data needed in planning and design may be found in Chapter 2, Appendix A. Visual changes in the landscape that result from channel work should be examined. The before and after appearance of the site should be documented and discussed with the local community and other interested individuals or groups. Procedures discussed in Chapter 8 shall be used for designing the visual resource.

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CHAPTER 2. FIELD SURVEYS & PLAN LAYOUT

General

Objectives of the Engineering Survey

The surveys for channel improvement work should be in sufficient detail to:

1. Determine the location, hydraulic properties, visual characteristics and condition of existing channels and associated structures.

2. Determine the needed improvements on existing channels and the required additional channels and appurtenant structures.

3. Determine the cost of the needed improvements.

4. Prepare suitable landrights work maps for easements and working permit requirements.

These objectives apply to both planning surveys and final design surveys and differ only in the amount of detail and precision needed for the respective stages of project development.

Preliminary Surveys

Information Needed

To accomplish the objectives stated above, the following information is needed for planning channel work:

1. Drainage area at junctions of tributaries and all flow control points. Drainage areas also should be delineated for valley sections used for hydrologic and economic evaluations where these are needed at locations other than at junctions of tributaries and structural control points.

   The drainage area determinations, including those needed for drainage purposes, should be made carefully for use in both the planning and the final design stages of the project.

   Where topographic quadrangle maps are available they are usually sufficiently accurate for delineating and planimetering the required drainage areas, except on extremely flat land. Field surveys may be required to determine watershed divides on flat land. Where feasible, the delineation of drainage areas should be checked by means of a stereoscopic study of 4-inch or 8-inch = 1 mile aerial photos.

All maps, especially in flat topography, should be field checked. This step should be done preferably in the preplanning stages to avoid the need for revisions as the planning work progresses.

2. Approximate profiles of the existing channel showing the elevation of the existing channel bottom, low bank, points of natural low ground away from, but subject to, drainage into the channel, and elevation and dimensions of all structures in or over the channel. In flat areas, occasional topography or perimeter and spot elevations may be needed to determine the drainage pattern. Existing tributaries should be located and sufficient bottom and ground elevations obtained to permit correlation of hydraulic gradelines and design of any grade control structures that may be needed.

3. Representative channel and valley cross sections for each hydraulic or economic reach. Additional channel cross sections should be taken as needed for reliable estimates of quantities of excavation and clearing, to determine easement requirements.

4. Mannings coefficient "n" for each channel and valley cross section. The "n" value should be representative of the hydraulic reach to which the section applies, except that where segments of a cross section differ significantly in flow retardance factors either within the channel, between the channel and the flood plain, or between segments of the flood plain, separate "n" values should be recorded for each segment.

5. The location and elevation of all soil investigation sites along the proposed channel.

6. The location of viewpoints and viewsheds along the proposed alignment.

7. The landscape character and use patterns along the alignment.

8. Stationing and delineation of apparent ownership boundary lines in the vicinity of probable channel improvement work.

9. Data including-dimensions, elevations, kinds of material, and condition of existing structures such as bridges, culverts, drops, and dams.

10. Data including acreage and density of brush, trees and debris on clearing required.

11. Other significant features affected such as roads, pipelines, power and telephone lines, buildings, wells, cemeteries, and fences. Such features should be located on aerial photographs or base maps and the elevations of strategic points recorded.

Survey Procedures

The survey procedure for "Preliminary Surveys" outlined in the National Engineering Handbook Section 16, 2/Chapter 2, is applicable. This procedure should be augmented by "Landscape Architecture Survey and Analysis" as outlined in Chapter 2, Appendix A. Technical Release-62, (TR-62), contains guidance for notekeeping and stationing.

Horizontal Control

Where suitable 8-inch aerial photographs or photo mosaics are available which show sufficient detail to locate and identify an existing channel that can be used as a base line, it will not be necessary to run a transit traverse in the planning stage to establish a base line. Other existing maps or plans of equivalent accuracy sometimes are acceptable for this purpose.

Horizontal control for the planning and design of stream channel work varies with the survey method selected. In most cases, sufficiently accurate horizontal control can be obtained from semicontrolled photo mosaics for both planning and preliminary design of channel work. The photo mosaic also may be used to show drainage areas, flood plain area, control elevations, channel locations, land ownership, etc.

The following steps are involved in obtaining semicontrolled photo mosaics:

1. Using the latest available aerial photos of the flood plain (preferably the 4" = 1 mi. scale), select two points near the center of each aerial photo, which can be identified on both the aerial photo and on the ground. These points should be at least 500 feet apart and, preferably parallel with the flood plain. Some additional accuracy may be obtained by selecting a second line, approximately perpendicular to the first, on each photo. To facilitate identification and measurement, these lines should be selected along established lines, such as roads or fences. Also, delineate the approximate area of the flood plain on the aerial photos.

2. Measure the distance to the nearest foot between the selected points in the field. Stadia distances may be used for lines up to about 1000 feet long. Identify the points on the photos by a small pin prick at each point. Circle the pin points on both the front and back of the photo. Also, number or letter each point for identification and mark the distance between the points on the back of each photo. For a permanent reference, record each measurement in a field notebook as follows:

Photo No.	Date	Point	Line	Approx. Brg.	Length	Description
DGB-2E 110	27 Apr. 1949	A				¢ rd. at bridge Roanoke Chan.
			A-B	NE	548'	
		B				N.W.cor.fld.N. of rd. and E. of Chan.
DGB-2E 112	27 Apr. 1949	C				S.W.cor.fld.with N-S lines, N. of Roanoke Chan.
			C-D	ENE	942'	
		D				S.E.cor.fld.with N-S lines, N. of Roanoke Chan.
DGB-2E-4S	27 Apr. 1949	E				¢ rd.in line with N-S fence W. of barn about 300' W. of rd. junc.
			E-F	SSW	736'	
		F				¢ rd.in line with N-S fence on W. side of L-shaped fld. S. of rd.

3. Have prepared from these photographs a semicontrolled photo mosaic of the flood plain to a scale not smaller than 1" = 400'. A film positive should be prepared of the aerial mosaic on 22" x 30" planprofile sheets with the aerial mosaic as the plan portion of the sheet. At least two copies of each film positive are suggested-one for use in preparing a problem location map and profile of the channel and flood plain, and the other for use in preparing the location plan and profile of channel improvement. Also, ozalid prints of each sheet are suggested for use, as working copies by all planning specialists in planning and evaluating project works of improvement.

4. In areas for which USGS topographic maps (scale 1" = 2000') have been completed recently by photogrammetric methods, the aerial mosaic may be semicontrolled to these USGS quadrangle sheets. In this case, the steps outlined in items 1 and 2 above would not be needed.

Where semicontrolled photo mosaics are used for horizontal control, the location of stream channel improvement may be shown on these mosaics. Other existing maps or plans of equivalent accuracy sometimes are acceptable for this purpose.

The following steps are needed:

1. Draw a preliminary centerline in pencil on the mosaic, showing curves, intersecting angles, etc. Plot and measure intersection angles by the tangent method for accuracy. To locate the center of curvature accurately, erect perpendiculars - do not use triangles.

2. Walk the full length of the flood plain, noting on an ozalid print of the aerial mosaic:

   Probable channel realignment,
   Points of significant breaks in grade,
   Location of all channel cross sections obtained with a hand level,
   Location of all rock outcrops or critical soil conditions,
   Approximate locations where valley cross sections may or should be obtained,
   Location of significant tributary junctions and places where side inlets may be needed,
   Location of all homes, institutions, roads, parks and recreation areas that maybe effected by the channel work. These include but are not limited to facilities that are within 500 feet of the alignment,
   Location of tree areas and large individual trees adjacent to the alignment,
   Location of utility crossings, such as: powerlines, telephone lines (aerial or buried) and pipelines. Obtain hand-level cross section of the channel at all visible pipeline crossings to show general relation of the pipeline elevation with the present channel bottom and bank elevations, and
   Location of fence lines and/or apparent property lines, foot bridges, etc., if not already visible on aerial photo.

3. Make a photo record of the landscape surrounding the project and record the viewsheds of the project from view points.

4. Following the field check, accurately establish the revised centerline on the photo mosaic. The final selection of alignment should be based on full use of all cross section, geologic and environmental data.

5. Show the actual location of all surveyed cross sections on the photo mosaic.

If suitable aerial photographs are not available it will be necessary to establish a base line in the field by means of an instrument survey. Where feasible, the base line should be located close to the improvement area but outside of brushy or wooded areas and any probable construction areas. This will facilitate survey work and avoid the necessity of establishing a new baseline at the time of construction. This is usually done by staking a series of tangent lines offset a convenient distance from the centerline of the existing channel. It is recommended that all points of intersection (PI's) of the tangent lines be staked with metal pins, when practicable, for later use in final design and construction layout surveys. A closed traverse survey should be made on this baseline. For closed traverse surveys, the error of angular closure should not be greater than $1.5\sqrt{N}$ minutes, N being the number of angles in the traverse. Horizontal closure of chained distances should not exceed 1.0 foot per 1000 feet of traverse length. All traverse angles should be doubled and checked by comparing computed bearings with observed magnetic bearings.

The use of a coordinate system will often facilitate the drafting and layout of complex horizontal controls. The coordinates should be related to existing systems in the area, where established, or to an assumed origin located so that all traverse points will plot in the same quadrant.

Vertical control

Vertical datum. - - Mean sea level datum is recommended for all channel improvement work.

Bench marks. - - Reasonably permanent bench marks should be established in the work plan stage at tributary junctions, at or near bridges or culverts where channels intersect roads, and at the beginning and end of channels. In addition, bench marks are suggested at approximately one-half mile intervals along the valley to facilitate the survey of valley cross sections and the preparation of an adequate profile.

All bench marks should be set by making turns through each bench mark; they should never be set by side shots from the level circuit. Level circuit surveys should be closed within the required degree of accuracy. The bench mark may be a plate or cap set in concrete, a plate on a concrete post similar to those used by USGS, or other similar means that will give the same degree of permanency. Manufactured survey markers, consisting of metal stakes with bronze caps are sometimes used because they are relatively inexpensive and can be set quickly and easily. Where manufactured markers are not used, it is advantageous to tag each bench mark with an aluminum tag showing the bench mark number and elevation.

Permissible error of closure. - - For most channel work, vertical control is of paramount importance. Channel designs are dependent upon the amount of fall between hydraulic control points. Therefore, "third order" leveling (i.e., .05 times the square root of the length of level circuit in miles) should be maintained for all bench level circuits, including subcircuits within larger circuits. These bench marks should be established to the specified degree of accuracy in the planning stage for use in both the planning and final design surveys.

Stationing

Main channel. - - The base line should be stationed in conformance to Engineering Memorandum SCS-39.

Where semicontrolled aerial mosaics are used to show the location of channels, mark the stationing on the centerline with a short dash at each 200-foot point.

Determine the stations at all cross sections and the pertinent features noted during the field reconnaissance by scaling the distances between points on the aerial mosaic. Although the points and the cross sections may be numbered both on the mosaic and in the notebook, these points also should be stationed in the field notebook as a permanent record. Thus, complete profile notes are obtained without actually measuring the distances in the field.

Where preliminary location surveys are obtained by means of an instrument survey, stationing is accomplished by measuring with a chain or stadia in the field.

Tributary channels. - - Base lines on tributary channels should be tied into the main channel base line.

Reaches

The length of design reaches normally is governed by the distance between points where a change of elements of the channel occurs, such as the entry of a side tributary or a change in gradient, depth, width, etc. Where the elements of a channel are constant for relatively long distances, the reach should be subdivided so that no design reach will exceed about 1/2 mile in length.

Cross Sections

Valley flood plain. - - The survey of valley cross sections used to develop water surface profiles for damage evaluation should be extended on each side of the valley to be above the maximum high water mark to permit computation of flood plain storage and to establish the vertical relationship between viewers and the channel work. Normally, this work is done in sufficient detail in the planning stage to serve for both the planning and final design requirements.

Sufficient points should be surveyed to represent adequately the hydraulic and visual characteristics of the cross section. Elevations should be established at all significant changes in slope. The distance between points on the cross section should not exceed 300 feet where the slopes are relatively uniform.

Channels. - - Channel sections are required to make reliable estimates of quantities and to determine easement requirements. They should extend far enough to permit improved channel alignment without additional surveys or at least 50 feet beyond the expected right-of-way, whichever is greater. The allowable distance between cross sections will vary with channel and valley conditions. Normally, 300 to 1000 feet are sufficient for work plan estimates. These sections should be tied into the same basic datum as the other sections in the watershed.

Structures

The condition and serviceability of all structures should be recorded. Adequate survey data are needed for all bridges and culverts in order to compute the carrying capacity for each. A minimum of three cross sections is needed at each structure; i.e., an inlet or approach section, a section perpendicular to the direction of flow through the structure, and an exit section. The entrance and exit sections usually are taken approximately 50 feet from the respective ends of the structure. The section through the structure should include the size of the opening, size of bridge piers, abutment footing elevations, and elevations of the bottom of bridge girders and the road surface. This section should be extended along the centerline of the road on either side of the structure beyond any probable overflow elevations. The grade and length and invert elevations of all bridges and culverts also should be obtained. See National Technical Release 14.

The three sections described for bridges and culverts also should be taken for all grade control structures along the channel. Similarly, cross sections are needed for all rock ledges which act as grade or hydraulic control sections.

Visual Resources

The data necessary to identify, plan, and design the visual resources will vary considerably among projects and may vary among parts of the same project. For example, given a flat terrain covered solely by a crop pattern with only stream way trees, the needed data may include only recording the possible road viewsheds and noting how the treetop edges contribute visual variety or a visual sense of space. However, in an urban landscape it may be necessary to pinpoint the locations of landscape elements such as large trees, accoustical and visual screen shrub masses, and landforms. Landscape architecture survey outline including a visual resource survey appears in Chapter 2, Appendix A. A more detailed discussion of visual resources and landscape architectural design appears in Chapter 8.

Plotting Data

General. - - Plan, profile, and cross section data obtained during the planning stage should be neatly plotted for use in preparing preliminary drawings. The scales used for plotting the data should be selected so that the information can be clearly shown on as few sheets as practical

Plan data. - - The plan should show the location of the existing channel; base line; cross sections; apparent property lines; general land use of adjacent areas; bench marks; existing vegetation, noting general size and specie, especially individual trees with greater than 6—inch diameter and trees with less than 6-inch diameter that are unique or not common for the watershed; roads, bridges and culverts; houses and institutional buildings that are within or adjacent to right-of-ways; and any utilities that may fall within the planned right-of-way. The base line should show either azimuths, bearings, or deflection angles. They may be shown as traced from aerial photographs. The direction and stationing of the cross sections should be shown on the plan. The plan may be made from an overlay of corrected 8-inch aerial photographs, plane table sheets, or a plot made from transit survey field notes. If coordinates are used, they should be shown on the plan.

Profile. - - Data obtained from the survey of valley cross sections and cross sections surveyed at hydraulic structures, supplemented if necessary with information from available USGS quadrangle sheets, should be used to plot a profile of the existing channel and valley. Standard sized sheets of profile paper or plan-profile paper should be used for this purpose, to facilitate preparation of preliminary drawings. (See Figure 2-1.)

The profile should show the water surface of the design flood for present conditions; the present ground line; the existing bottom grade; cross section locations; soil investigation sites; the elevation and location of any exposed or underground utilities, roads and existing or proposed bridges and culverts, junctions of tributaries; etc.

It may be desirable to plot separate profiles for use in considering existing and planned conditions if it is expected that existing alignment will be changed significantly.

Cross sections. - - Cross sections should show any existing channels; the intersection with the base line; the elevation of the design flood for existing conditions; the elevation of any exposed or underground utilities; and any existing or proposed bridges.

<u>Preparation of Preliminary Drawings</u>

Preliminary drawings may include plan, profile and cross sections of all channel work proposed for the project. In the case of large complex channel systems, it may be expedient to show only representative channels in this degree of detail in order to reduce the bulk of the preliminary document.

In either case the following preliminary design data should be shown in addition to the survey data collected as shown above:

1. Proposed channel alignment with bearings or azimuth should be shown for each tangent. Curve data is usually not needed at this stage or development.

2. Proposed grade and water surface profile should be shown on the profile including pertinent elevations and invert gradient.

3. Typical cross sections showing existing and proposed sections one for each type or size of proposed section should be included on each sheet of plan-profile.

4. If structures are proposed for the project, a drawing of a typical structure showing general dimensions should be included.

5. Drawings, sketches, cross sections or photo montages should be included to illustrate how the proposed project will appear in the surrounding landscape.

Profile and cross sections may be omitted in reaches to be cleared and snagged only.

A horizontal scale of 1 inch = 200 ft. to 1 inch = 1000 ft. for plan-profile is usually adequate for preliminary drawings. If the original plot of survey data can be made to the same scale as that needed for drawings, considerable time and effort will be saved.

Documentation

All data developed during the planning phase should be properly documented and filed. This will insure that such data will be of maximum use for future reference. All notes, computations, and drawings should be properly identified and be complete so that they can be used in preparing detailed plans for design and construction. The data should be dated, since Service criteria are modified from time to time. All papers should show the initials of the person preparing the data sheets or making the computations. A reference should be made to indicate the methods or source of data used.

Survey for Final Design

General Requirements

The section covering "Design Surveys - Surface Drainage" in the National Engineering Handbook Section 16, 2/ Chapter 2, will serve as a useful reference for final design surveys, where applicable. As indicated in the NEH, a staked base line is required. An exception to this requirement may be made where clearing and snagging is the only work needed to provide the desired level of protection. For this condition, no additional surveys over those recommended for planning may be needed for design purposes. However, sufficient data must be obtained to permit the determination that this treatment will result in a stable channel which will meet the desired project objectives.

Field Check of Design Layout

For most projects it is highly desirable to check the final design on the ground. Verify the following:

1. Alignment and stationing.

2. Rights-of-way boundaries.

3. Construction easement limits.

4. Structure locations.

5. Stationing and description of bench marks.

6. Utility locations.

7. Apparent ownership boundaries.

8. Woody vegetation locations, including individual large and/or unique trees.

9. Home and institutional locations when potentially visible from the project site.

Land Rights Work Maps

The land rights work map may be prepared by making a full scale or photographically reduced overlay of the appropriate portions of the strip map. Judgment must be exercised to insure that adequate land rights are provided for the channel, spoil bank area, visual design areas and the maintenance and construction operations.

Except where specified otherwise in existing state laws, the land rights work map should show the existing channel, utilities, apparent ownership boundaries, roads, base lines showing key stations, and proposed works of improvement. If requested by the sponsors or required by state law the apparent acreage of right-of-way for each landowner should be indicated on the land rights work map.

A typical cross section should be shown on the land rights work map to illustrate the various elements of the proposed works of improvement within the right-of-way area. When utilities are involved, the actual cross section including the elevation of the design flow should be shown at the intersection with the utility.

Supplementing Planning Surveys

Field survey data obtained in the planning phase must be supplemented to provide basic design data. In fact, budgetary considerations will often preclude much of the detail described above for the planning phase so that the survey data used in preparing preliminary drawings may be of little value as design data.

Supplemental data needed to establish the visual resource design may be determined by the outlines shown in Chapter 2, Appendix A.

Bench levels must be checked and supplemented. Damaged BM's should be reestablished and additional bench marks should be set and tied in as needed.

Coordinate control should be established by traverse and closed within third order accuracy. Triangulation may be used to establish control on large, complex projects, if desired.

Topographic strip maps of the area will be needed for layout and design. Data for these maps may be secured either by plane-table or transit topography tied to the traverse. Strip map data must be secured to provide accurate location of contours, fences, buildings, bridges, culverts, roads, utilities, the edges of woody vegetation areas, large trees, orchards, existing drainage or irrigation ditches and structures, and all other physical or man-made features within the probable limits of work.

Test pits and borings should be accurately located and the elevation should be established on a reference hub adjacent to the site.

Preparation of Strip Maps and Profile

Strip maps should be plotted to the same scale as that intended for final drawings - usually 1 inch = 40 ft. to 1 inch = 200 ft., depending on the detail needed. For convenience, strip maps should be plotted on transparent paper or cloth sheets not exceeding 42 inches in width and 20 ft. in length. This provides sufficient length for proper selection of long tangents and curves for the "paper location."

Trial locations complete with stationing and curve data are then superimposed on prints of the strip maps and profiles are plotted on equally long profile sheets to permit selection of long tangent grades.

As the hydraulic design progresses and design cross sections are selected one of the alternate locations will usually emerge as apparently superior. The best apparent alternate including right-of-way requirements should then be drawn on the strip maps. Design grades and cross sections should be drawn on the strip profile. Prints should then be made of both the maps and profiles for field checking, prior to tracing final drawings on standard sheets.

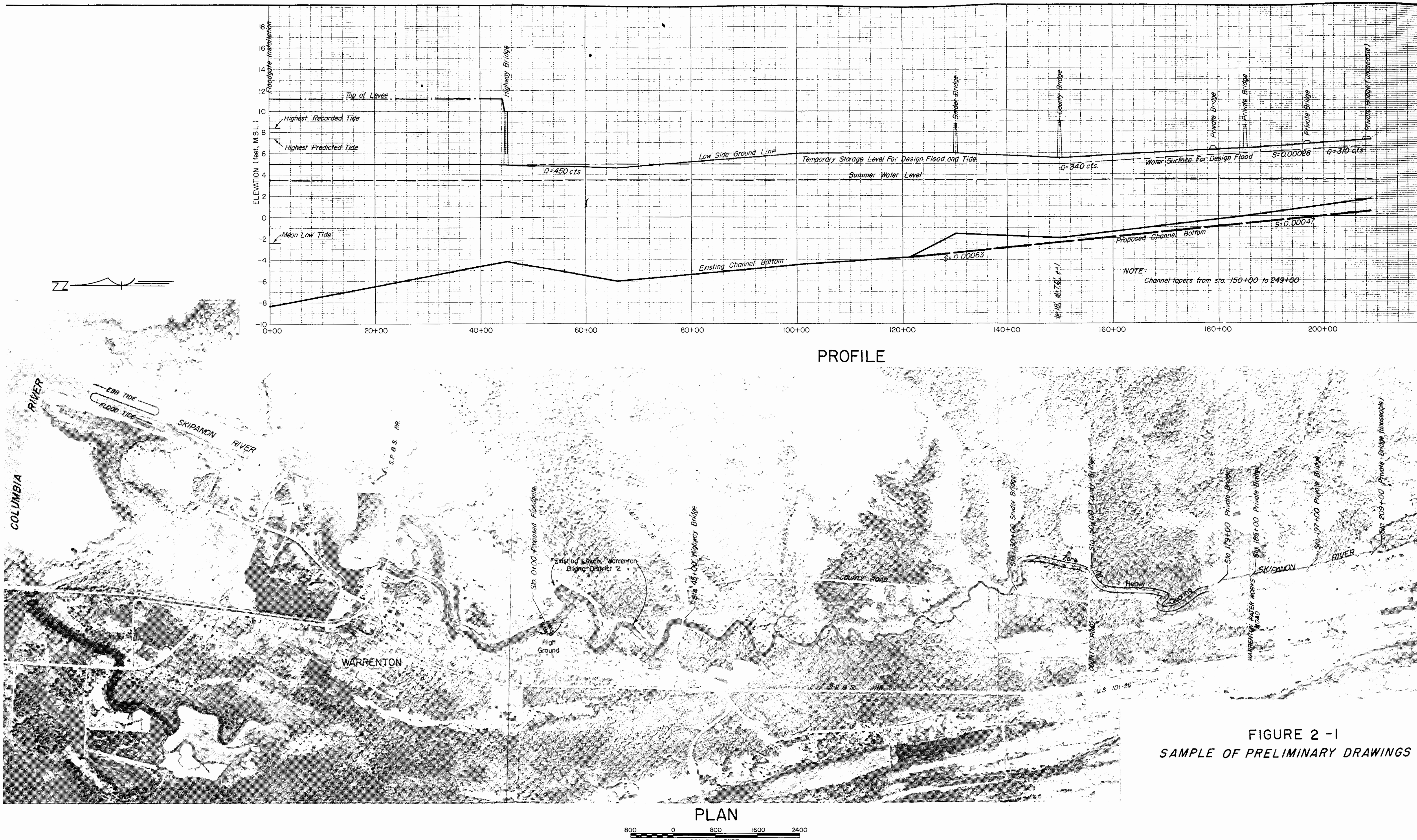


FIGURE 2 -1
SAMPLE OF PRELIMINARY DRAWINGS

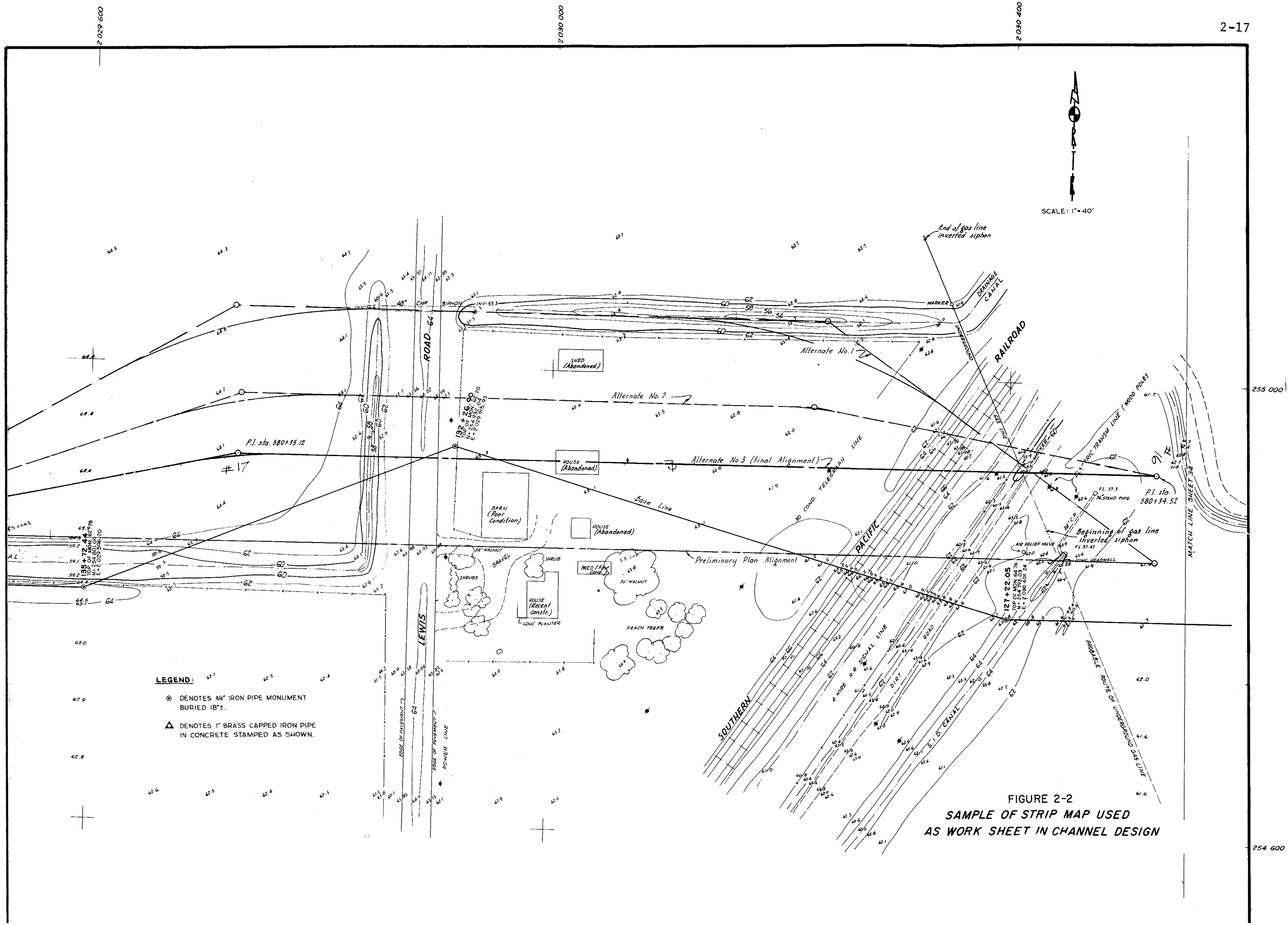


FIGURE 2-2
SAMPLE OF STRIP MAP USED AS WORK SHEET IN CHANNEL DESIGN

17-927 O - 78 (Face blank p. 30) No. 2

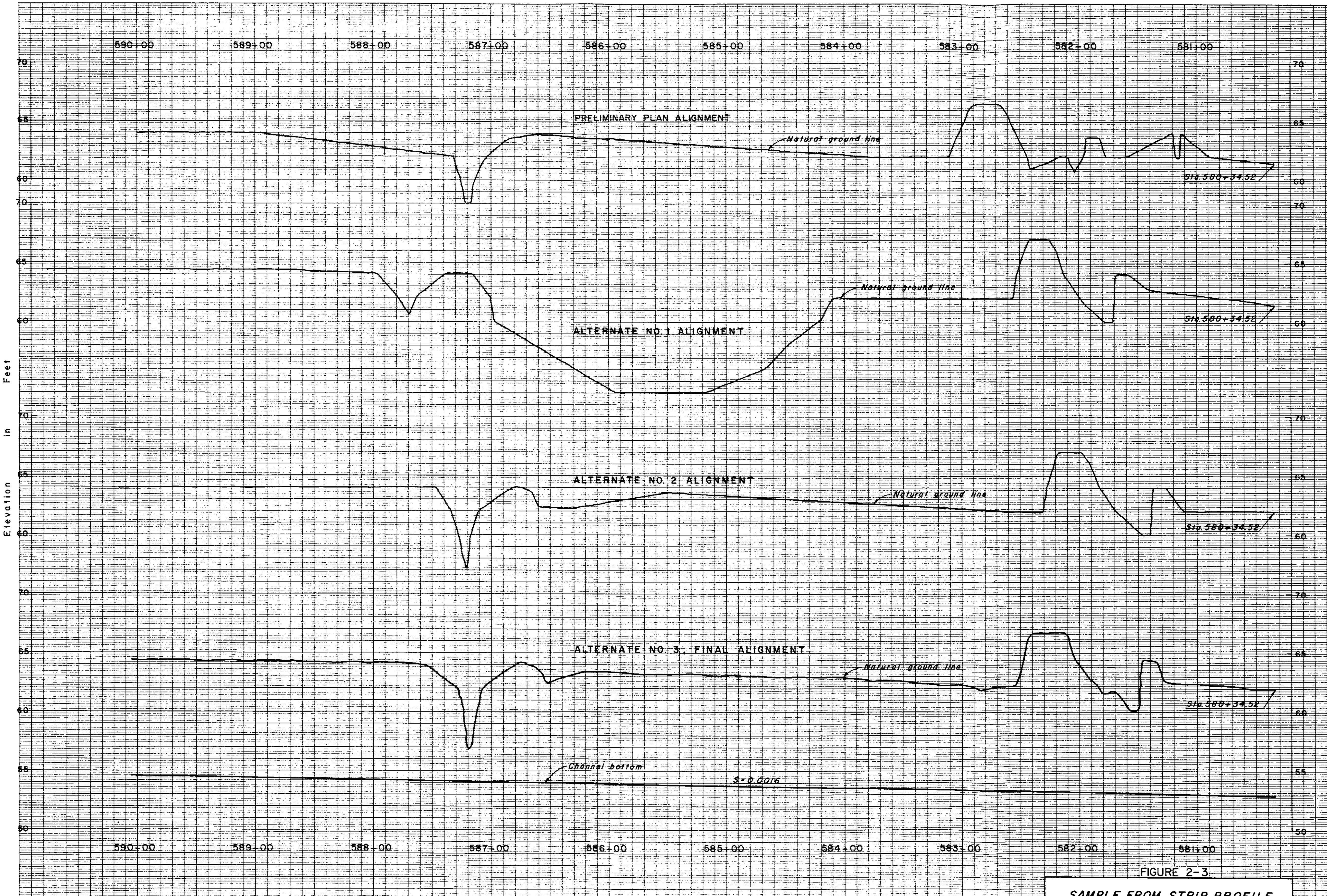
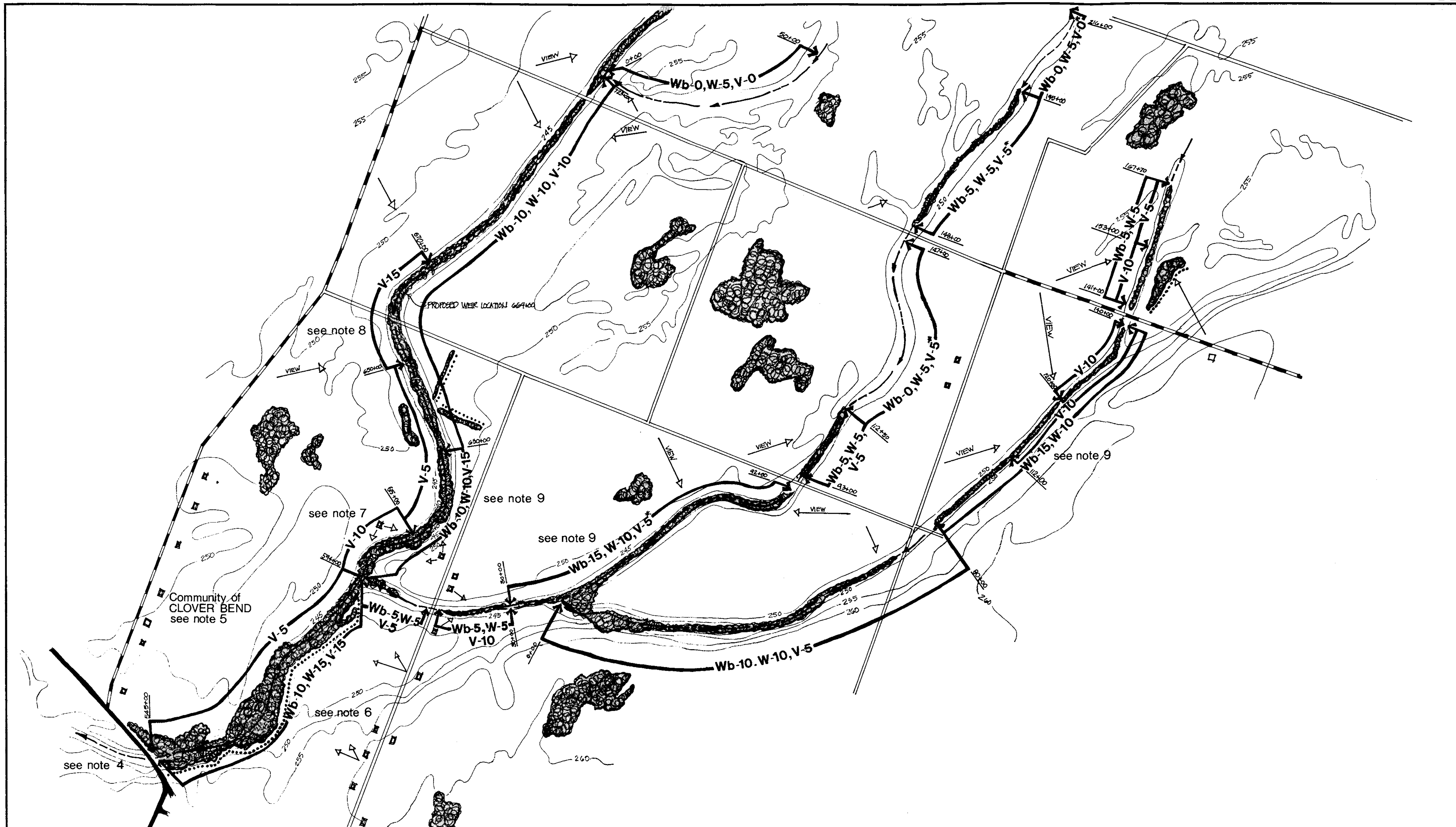


FIGURE 2-3

SAMPLE FROM STRIP PROFILE
(DESIGN WORK SHEET)



NOTES

1 THE PURPOSE OF THIS SHEET IS TO IDENTIFY GRAPHICALLY THE RESOURCE VALUE OF LANDSCAPE ELEMENTS OCCURRING WITHIN OR ADJACENT TO THE R/W'S OF CHANNELS PROPOSED FOR MODIFICATION UNDER THIS CONTRACT.

2 THREE MAJOR RESOURCES WERE STUDIED. (1) WINDBRAKE RESOURCE, (2) WILDLIFE HABITAT RESOURCES, AND (3) VISUAL RESOURCES.

3 THE RELATIVE VALUE OF EACH RESOURCE CAN BE IDENTIFIED AT ANY POINT ON THE CHANNEL TO BE MODIFIED. (SEE LEGEND FOR IDENTIFICATION OF SYMBOLS.)

4 STATE HIGHWAY #228 IS ELEVATED ABOVE THE CHANNELWAY APPROX. 20 FT SO THAT OBSERVERS WILL BE LOOKING DOWN ON CHANNEL. (TIME OF VIEWING @ 50 MPH IS 5 SEC.) CHANNEL ALIGNMENT IS SUCH THAT LENGTHY DOWN CHANNEL VIEWS WILL BE CREATED. *SELECTIVE TREES COULD BE LEFT WITHIN THE CLEARING LIMIT TO BREAK UP SIGHT LINE DOWN CHANNELWAY. * SPOIL PLACEMENT AND SHAPING SHOULD BE PERFORMED TO SIMULATE MORE NATURAL LAND FORM CHARACTERISTICS.

5 THE CHANNELWAY, INCLUDING WOODLAND EDGES IS NOT SIGNIFICANTLY VIEWABLE FROM PAVED COUNTY ROADWAY OR RESIDENCES WEST OF PROPOSED CHANNEL MODIFICATION. THUS THE LOW VISUAL VALUE RATING FROM STATION 545+00 TO 599+00.

6 THE CHANNELWAY (PARTICULARLY THE WOODLAND EDGE) IS IN CLOSE PROXIMITY TO A GRAVELLED COUNTY ROADWAY AND A NUMBER OF RESIDENCES. SIGHT LINES ARE PRIMARILY PERPENDICULAR INTO WOODLAND EDGE. VISUAL QUALITY IS HIGH BECAUSE OF THE WIDE SECTION OF WOODLAND AREA (200-800 FT.). CHANNEL MODIFICATION WILL BE SCREENED FROM VIEW AND VISUAL QUALITY WOULD NOT BE ALTERED. * CLEARING SHOULD BE LIMITED TO THE MINIMUM NEEDED FOR EXCAVATION AND SPOIL SPREADING ON BOTH SIDES.

7 VISUAL VALUE OF WOODLAND EDGE RATED PROXIMITY MODERATE BECAUSE OF RESIDENCE. * NEED TO RETAIN TREE LINE TO SCREEN CHANNEL WORK.

8 WOODLAND EDGE HIGHLY VIEWABLE FROM STATION 650-00 TO 670-00, THUS VISUAL RATING OF 15. * SHOULD ATTEMPT TO MAINTAIN TREE LINE EDGE ON ONE SIDE.

9 ON REACHES OF THE CHANNEL WHERE ANY RESOURCE VALUE IS RATED @ 15 I.E., WB-15, W-10, V-5, CONSTRUCTION SHOULD BE LIMITED TO ONE SIDE FOR RETENTION OF WOODS ON OPPOSITE SIDE. * RETENTION OF WOODLAND EDGE FOR ONE PURPOSE OR ANOTHER WOULD NORMALLY BENEFIT OTHER RESOURCES.

KEY

- STATE HWY. MODERATE TO HEAVY DUTY
- PAVED COUNTY RD. MODERATE TO LOW DUTY
- GRAVELLED COUNTY RD. LOW DUTY
- CONTOUR LINE (5 FT. INTERVAL)
- RESIDENCE
- WOODLINE
- SCREENING EFFECT OF WOODS OUTSIDE CHANNEL R/W
- VIEW — SIGHT LINES OF SIGNIFICANCE
- LIMITS OF VALUE RATINGS

Wb	WINDBRAKE
W	WILDLIFE HABITAT
V	VISUAL RESOURCE
V*	ASTERIC DENOTES VISUAL VALUE RATING AS VIEWED FROM EITHER SIDE OF CHANNEL

RATING:

15	HIGH VALUE
10	MODERATE VALUE
5	INSIGNIFICANT
0	LOW VALUE

FIGURE 2-4

SAMPLE LANDSCAPE VALUE SURVEY

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
Drawn		Title
Traced		Title
Checked		Sheet No. of — Drawing No.

147-927 O - 78 (Face blank p. 30) No. 4

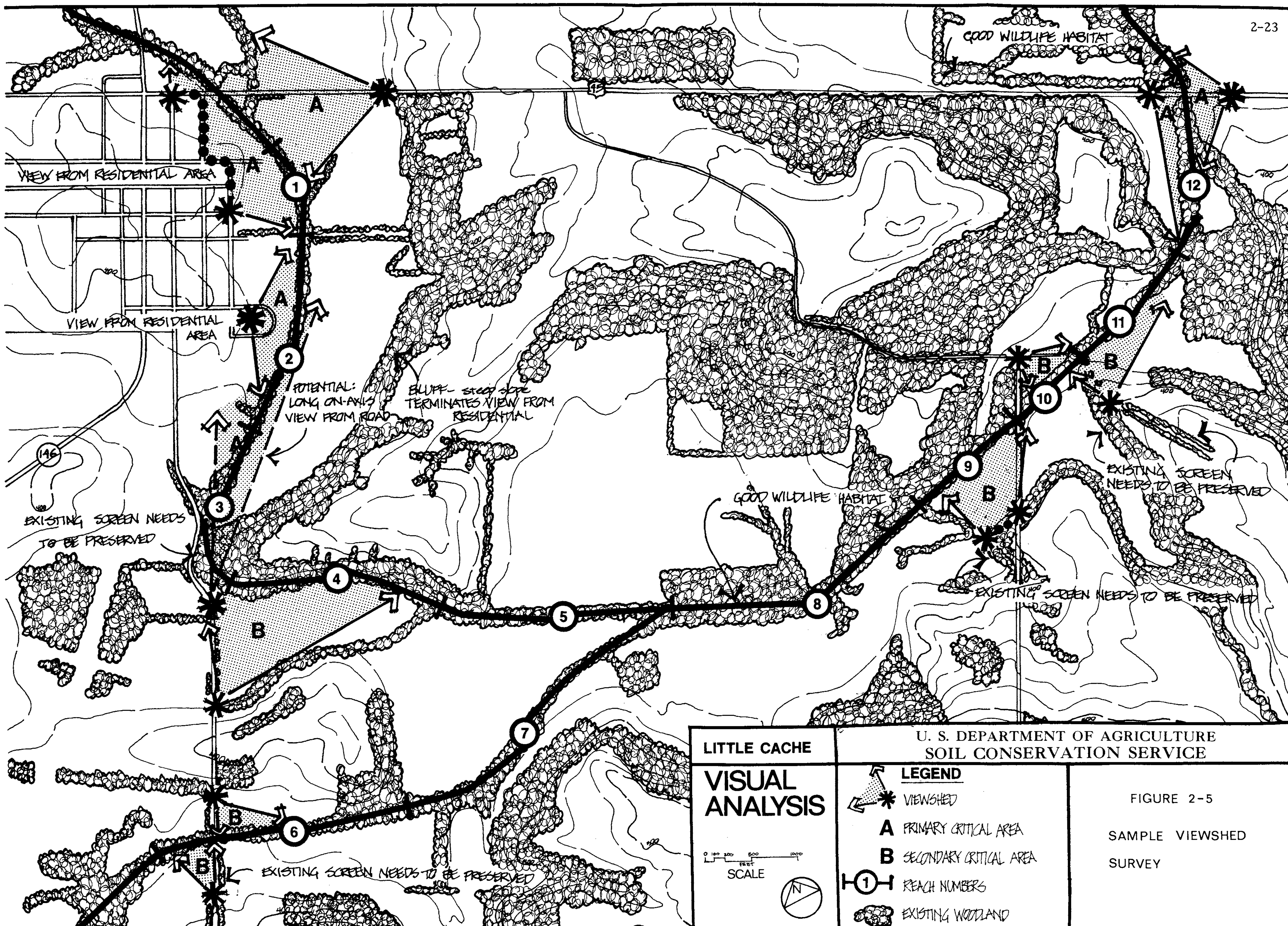


FIGURE 2-5

SAMPLE VIEWSHED SURVEY

O - 78 (Face blank p. 30) No. 5

Visual Conditions Before Construction: Winter

Visual Conditions After Construction: Winter

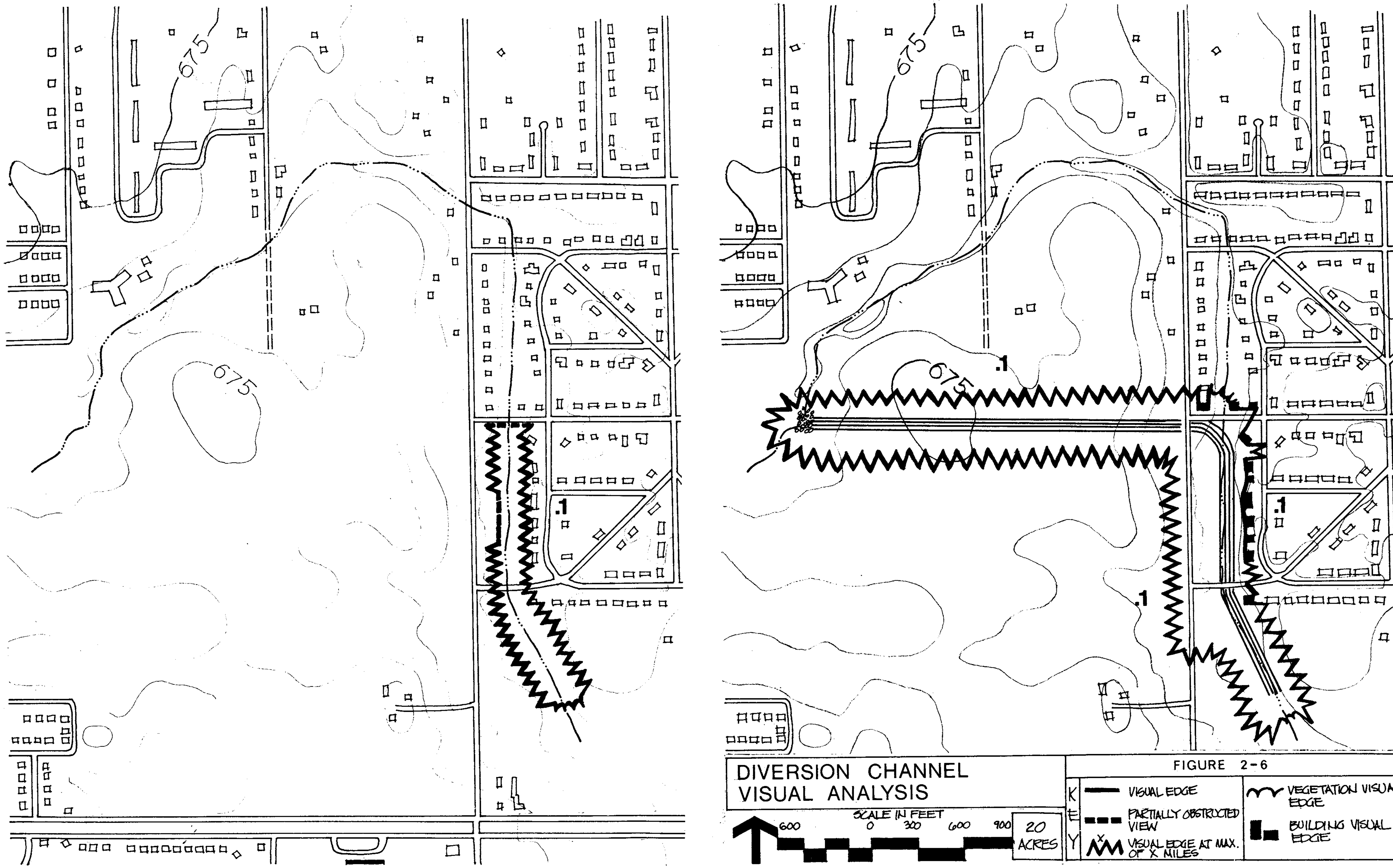


FIGURE 2-6

DIVERSION CHANNEL VISUAL ANALYSIS

- 78 (Face blank p. 30)

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CHAPTER 2. APPENDIX A.

LANDSCAPE ARCHITECTURE SITE SURVEY AND ANALYSIS

INTRODUCTION

The goals of landscape architecture are to identify, analyze, plan and design so as to retain, replace, or improve as many landscape resource values as possible. Material in this Appendix will cover the identification and analysis procedures. Planning and design will be discussed in Chapter 8. Material presented in this technical release assumes prior landscape architectural inputs have occurred in the development of project alternatives. Some of the material discussed herein could be used in the initial project assessment phase.

Meeting the goals of landscape architecture in channel work does not always mean a channel should be built to appear as it did before the project or necessarily to appear as a "natural landscape." The project site appearance can change drastically, as long as the landscape resource values have been retained, replaced, or improved. To achieve these goals the following four step procedure should be followed:

1. Landscape Architecture Site Survey to identify and map the landscape use and visual resource values* and to modify these values as indicated by project visibility.

2. Landscape Architecture Site Analysis to identify opportunities and problems and to define objectives so as to utilize opportunities and overcome problems.

3. Planning to identify alternates that achieve the objectives. In this phase the landscape architectural objectives merge with other engineering objectives to find the best possible alternatives.

4. Design to detail the chosen alternative so as to achieve the best structural and environmental solution.

LANDSCAPE ARCHITECTURE SITE SURVEY

Any landscape architecture (LA) site survey includes two basic factors the landscape (its physical characteristics) and people (how they see and use the landscape.) Judgment should be used to determine what data are needed. Obviously the scope and detail of the data will vary depending upon the size and location of the channel. Both the explict value of the landscape and some sense of the landscape's implicit value as perceived by its users and viewers must be considered in channel

* definition may be found in Glossary at the end of Appendix A.

work. For example, a channel may have a straight alignment and may be a previously dug ditch; but it may be perceived as valuable because it is used by the public as an open space. A LA site survey for channel work should cover the following factors:

1. Landscape Use Value
2. Visual Resource
3. Project Visibility

1. Landscape Use Value

The LA site survey should note how the existing project area is used by the public. In most cases, channel work can be designed so the landscape will retain its utility for human use, while improving its hydrologic characteristics. Data to be noted and/or mapped for various reaches include but are not limited to:

A. Identifying places where existing streamway vegetation function as a:

   (1) Shelterbelt to help control wind erosion.

   (2) Privacy screen between homes.

   (3) Buffer between incompatible land uses such as industrial and residential areas.

   (4) Noise barrier such as between homes and a busy highway.

   (5) Safety barrier controlling pedestrian traffic such as between schools and roads.

   (6) Climate shelterbelt such as a wind/sun screen providing energy conservation to homes and institutions.

B. Identifying areas along the streamway that function as or contain:

   (1) Pedestrian paths between homes, schools and commercial areas.

   (2) Recreation areas contiguous to existing playgrounds, schools and parks.

   (3) An open space or environmental corridor within a developed area.

2. Visual Resource (VR) Value

Investigating the visual resource values should not involve a personal judgment as to beauty. For example, a previously dug ditch might be judged as "ugly" and yet have high VR value because it provides variety in an otherwise monotonous landscape. A concrete drop structure may be judged "ugly" and yet have high VR value because it relates architecturally to the surrounding landscape. Visual resource value involves an assessment of several measurable factors. The factors cited in Rating Charts A-C below were developed from research and preference studies cited at the end of this Appendix. These charts must be used within a local frame of reference and must be verified by citizen participation. For example, water carrying sediment may appear relatively muddy or clear depending on the appearance of other streams within the area.

The Rating Charts A-C below rank VR values into only two groups, high or low. One or more middle groups do exist between high and low. These charts should be expanded into at least three groups and the criteria shifted to fit the locale. For example, crystal clear water (Chart B, item 1) may not exist in a locale. In that case, the clearest water for the locale should be rated as a high value visual resource and all other water clarity rated in comparison to it. Investigation of VR values include, but is not limited, to identifying and/or mapping the existing landscape as to the following.

RATING CHART A: Visual Resources of Streamway and Surrounding Landscape

Rural Areas

High Value Visual Resource	Low Value Visual Resource
(1) Adjacent landscape has no linear patterns, no agricultural activity, few or no manmade structures.	(1) Adjacent landscape contains many linear forms and patterns, (other channels, transmission lines, field patterns).
(2) Streamway has the major trees in the landscape providing the only variety and spatial definition to surrounding landscape.	(2) Streamway provides no spatial definition or variety to surrounding landscape.
(3) Surrounding landscape has no visual detractors (strip mining, derelect lands, erosion, etc.) and/or is highly maintained with obvious care for its appearance.	(3) Surrounding landscape has obvious visual detractors.

Urban Areas

High Value Visual Resource	Low Value Visual Resource
(1) Streamway area is highly maintained (lawn, shrubs and trees) and/or is a visual part of residential lots, school grounds and parks.	(1) Streamway area is not a visual part of any maintained area.
(2) Adjacent landscape is highly maintained with obvious care for its appearance (lawns, residential gardens, industrial parks).	(2) Adjacent landscape is derelict, poorly maintained with no obvious concern of its appearance.
(3) Large, mature and/or flowering trees along streamway.	(3) No significant woody plants along streamways.

RATING CHART B: Visual Characteristics of the Water

High Value Visual Resource	Low Value Visual Resource
(1) Clear, generally transparent water.	(1) Visible color or turbidity, and/or pollution and/or algae.
(2) Desirable drift material such as leaves.	(2) Floating debris and trash.
(3) Variety of bottom material (bedrock boulders, gravel or unique bottom material for area).	(3) Homogenous bottom material commonly found in all area streamways.
(4) Conspicuous water movement, rapids, riffles or slow movement with high reflecting ability.	(4) No open water, weed choked or imperceptible water movement with no reflecting ability.
(5) Variety of movement from fast reaches to still pools.	(5) Homogenous movement with no visible variety.

RATING CHART C: Visual Resources within the Streamway

High Value Visual Resource	Low Value Visual Resource
(1) Streamway is obvious, meandering visual edge in landscape.	(1) Previously dug straight ditch.
(2) Variety of streambank slopes.	(2) Uniform streambank slopes.
(3) Variety in size and shape of cross section.	(3) Uniform cross section.
(4) Unique streamway vegetation compared to surrounding landscape (cypress, beech, birch).	(4) Vegetation in streamway is weedy or commonly seen in surrounding lands scape.

3. Project Visibility

Investigate the types of viewers and their significant viewsheds* to determine how visible the project will be within a locale. Determining the public's opportunities to see the project will modify the use and visual resource values determined previously. The charts below are guides to identifying project visibility and evaluating its significance. The guides should be modified to fit a local context. For example, viewers who may see the project one time only may or may not need to be considered depending on the local frame of reference. Visibility factors to be noted and/or mapped include but are not limited to:

CHART D: Viewers

	Critical	Important	Normal
1. Purpose of seeing or being on project site	•Homeowner, including farmer •Recreationist •Tourist •Local resident	•Resident of region •Adjacent businessman •Students at school	•Farmer at work
2. Frequency of view	•Daily >1 min	•Daily <1 min •Infrequent but for longer time periods >1 hour	•Infrequently for short time periods
Speed of viewer	Slow such as •Pedestrian •Bicyclist •Canoe or slow moving boat	•Moderate 15-30 MPH	•Fast 30 MPH

CHART E: Viewshed and Viewpoints

		Critical	Important	Normal
1.	Viewpoint location relative to project	•Elevated as from bridge, road, or two story bldg. (> 20')	•Elevated < 20'	•Ground level
		•Scenic hwy or overlook	•Interstate, state or busy country roads	•County or farm road
		•From residential, institutional or recreational areas	•From isolated home or farmstead	•From commercial areas
2.	Location of project within viewshed	•Foreground* only •Foreground to background* or a long vista on channel	•Middleground* only •Middleground and background	•Background only

See Figures 2-5 and 2-6 for examples of viewshed maps.

LANDSCAPE ARCHITECTURE SITE ANALYSIS

The intensity of a site analysis will vary between projects but the following steps remain the same:

1. Locate opportunity and problem sites in the project area.
2. List in priority the landscape architecture objectives for both problem and opportunity areas.
3. Document the analysis in a supporting data file.

1. Opportunity and Problem Sites

Opportunity sites are defined as areas where the channel design may retain or rehabilitate existing landscape values. Problem sites are defined as areas where the channel design may reduce or eliminate existing landscape values. Opportunities and problems are located by superimposing landscape value areas (use and visual) and project visibility data. For example, an area of low visual resource value, moderate project visibility and high use may be an opportunity site; whereas an area of high visual resource value, high use, and moderate project visibility may be a problem area. The relative importance of the visual resource value, use value and visibility within the decision process can shift depending on the project. For example, retaining the use value of the landscape may be most important in some locations; while in other areas retaining the visual resource values may come first.

2. Landscape Architecture, (LA), Objectives

The LA objectives should be the logical outcome of the LA analysis, and a LA design, (Chapter 8) should be the logical product of the objectives. The success of the final design will depend on how well the site analysis has been done and how clearly the landscape architectural objectives have been stated. These objectives should be prioritized and stated as objectives, not design solutions. For example, an objective might be "to retain the climate shelterbelt value of urban trees." The various options for achieving this might include; moving the channel alignment, changing the side slopes to retain trees, selective clearing to retain the most functional trees or replanting with mature trees. The decision to choose among these design options should be correlated with other engineering factors in final design.

3. Documentation

Documentation of the site survey, analysis and objectives can be done on several formats: reports, maps with notes, photo record with notes, computer graphics or a combination of any of these. Often the analysis and documentation can be done in a single process by mapping with notes (See Figure 2-4). A photographic record of use and visual resource value areas and critical viewsheds should be done for all channels in urban areas or areas of projected future urban development.

GLOSSARY

1. BACKGROUND is the viewshed zone most distant from the viewer. Details are not seen in this zone. The horizon line is prominent in this zone as are general form, colors, and textures.

2. FOREGROUND is the viewshed zone nearest the viewer. It is the zone in which details, such as construction joints, movement of water and the finish of earth grading, are visible.

3. MIDDLEGROUND is the viewshed zone between the back and foreground. Some details can be seen in this zone but only those which are in sharp contrast visually.

4. VIEWSHED is the zone of view or volume in a given direction as seen from a specific viewpoint.

5. VISUAL RESOURCE is the appearance of the landscape as described by the measurable visual elements; topography, vegetation, water, and human structures and patterns, and by the measurable patterns of interaction among these elements.

6. VISUAL RESOURCE VALUE is the relative desirability of a visual resource unit as evaluated by rational criteria.

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CHAPTER 3 - APPENDIX

OUTLINE TO PLAN SITE INVESTIGATIONS AND PREPARE REPORTS FOR CHANNEL IMPROVEMENT